

## FIELD EFFECT TRANSISTER AND PROCESS FOR PRODUCING THE SAME

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from a Japanese patent application No. 2008-004950 filed on Jan. 11, 2008, the entire content of which is incorporated herein by reference.

### BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a field effect transistor comprised of a nitride based compound to be used for a device for power electronics and a device of high frequency amplification, and to a process for producing the same.

[0004] 2. Description of the Related Art

[0005] A wide band gap semiconductor representative of a III-V group nitride based compound is extremely attractive as a material for a semiconductor device for a high temperature, a large power, or for a high frequency, because of having a breakdown voltage as high, a electronic transport property as satisfactory, and a thermal conductivity as satisfactory. Moreover, regarding a field effect transistor (an FET) having an AlGaIn/GaN hetero structure for example, a two dimensional electron gas is generated in an interface due to a piezoelectric effect. The two dimensional electron gas draws attention because of high electron mobility and carrier density. Further, a hetero-junction FET (an HFET) using the AlGaIn/GaN hetero structure has a low resistance and a fast switching speed, so that it is possible to perform an operation at a high temperature environment. The features are suitable for an application of a power switching.

[0006] The ordinary AlGaIn/GaN HFET is a device of a normally on type, in which an electric current flows in a case where a bias is not applied to a gate, and then an electric current is cut off by applying a negative electric potential to the gate therein. In the application of the power switching, for securing safety, it is preferable to use the device of the normally off type, in which an electric current does not flow in the case where a bias is not applied to a gate, and then an electric current flows by applying a positive electric potential to the gate.

[0007] In order to produce the device of normally off type, it is necessary to adopt an MOS structure. For example, patent document has disclosed a field effect transistor having the MOS structure (an MOSFET), wherein a carrier supplying layer comprised of AlGaIn or the like is etched off at a gate, and an insulating layer is formed on an etched surface of a carrier drifting layer.

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[0008] In the field effect transistor disclosed in the patent document, a side wall of the carrier supplying layer thus etched off is formed approximately vertical to the etched surface of the carrier drifting layer. As a result, an electric field is converged at a corner part with right angle formed with the side wall of the carrier supplying layer and the etched

surface of the carrier drifting layer between the gate and a drain, thereby decreasing a breakdown voltage.

### SUMMARY OF THE INVENTION

[0009] The present invention is presented with regard to the above mentioned conventional problems, and an object is to provide a field effect transistor having a high breakdown voltage, and to provide a process for producing the field effect transistor.

[0010] For solving the problems and attaining the objects, according to the present invention, a field effect transistor is formed of a nitride based compound semiconductor. The field effect transistor includes a substrate; a semiconductor operating layer having a recess part and formed on the substrate; an insulating layer formed on the semiconductor operating layer including the recess part; a gate electrode formed on the insulating layer at the recess part; and a source electrode and a drain electrode formed on the semiconductor operating layer with the recess part in between and electrically connected to the semiconductor operating layer. The recess part includes a side wall protruding and inclined relative to the semiconductor operating layer.

[0011] According to the present invention, a process for producing a field effect transistor formed of a nitride based compound semiconductor includes the steps of: forming a semiconductor operating layer onto a substrate; forming a recess part having a side wall inclined relative to the semiconductor operating layer on the semiconductor operating layer; forming a source electrode and a drain electrode on the semiconductor operating layer with the recess part in between for electrically connecting to the semiconductor operating layer; forming an insulating layer on the semiconductor operating layer having the recess part; and forming a gate electrode on the insulating layer at the recess part.

[0012] In the present invention, it is possible to alleviate a localized convergence of an electric field between the gate and the drain, thereby obtaining the field effect transistor having a high breakdown voltage.

[0013] The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a cross sectional view showing an MOSFET according to a first embodiment;

[0015] FIGS. 2A to 2F are views showing one example of a process for producing the MOSFET shown in FIG. 1;

[0016] FIG. 3 is a chart showing an angle at a standing up, an on-resistance and a breakdown voltage of MOSFETs according to Example 1-1, 1-2 and Comparative example 1, respectively;

[0017] FIG. 4 is a cross sectional view showing an MOSFET according to a second embodiment;

[0018] FIG. 5 is a graph showing a relationship between an angle at a standing up and an on-resistance of an MOSFET shown in FIG. 9;

[0019] FIG. 6 is a cross sectional view showing an MOSFET according to a third embodiment;